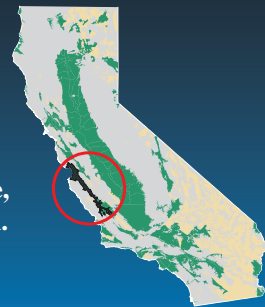


U.S. Geological Survey and the California State Water Resources Control Board

# Groundwater Quality in the Monterey Bay and Salinas Valley Groundwater Basins, California

Groundwater provides more than 40 percent of California's drinking water. To protect this vital resource, the State of California created the Groundwater Ambient Monitoring and Assessment (GAMA) Program. The Priority Basin Project of the GAMA Program provides a comprehensive assessment of the State's groundwater quality and increases public access to groundwater-quality information. The basins around Monterey Bay, and in the Salinas and Paso Robles Valleys, constitute one of the study units being evaluated.



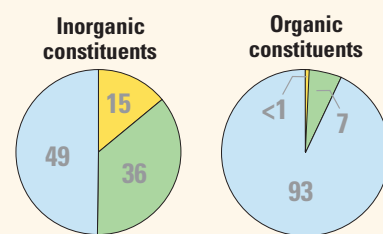
## The Monterey-Salinas Study Unit

The Monterey-Salinas study unit is nearly 1,000 square miles and consists of the Santa Cruz Purisima Formation Highlands, Felton Area, Scotts Valley, Soquel Valley, West Santa Cruz Terrace, Salinas Valley, Pajaro Valley, and Carmel Valley groundwater basins (California Department of Water Resources, 2003; Kulongoski and Belitz, 2011). These basins were grouped into four study areas based primarily on geography. Groundwater basins in the north were grouped into the Santa Cruz study area, and those to the south were grouped into the Monterey Bay, the Salinas Valley, and the Paso Robles study areas (Kulongoski and others, 2007).

The study unit has warm, dry summers and cool, moist winters. Average annual rainfall ranges from 31 inches in Santa Cruz in the north to 13 inches in Paso Robles in the south. The study areas are drained by several rivers and their principal tributaries: the Salinas, Pajaro, and Carmel Rivers, and San Lorenzo Creek.

The Salinas Valley is a large intermontane valley that extends southeastward from Monterey Bay to Paso Robles. It has been filled, up to a thickness of 2,000 feet, with Tertiary and Quaternary marine and terrestrial sediments that overlie granitic basement. The Miocene-age

## Overview of Water Quality

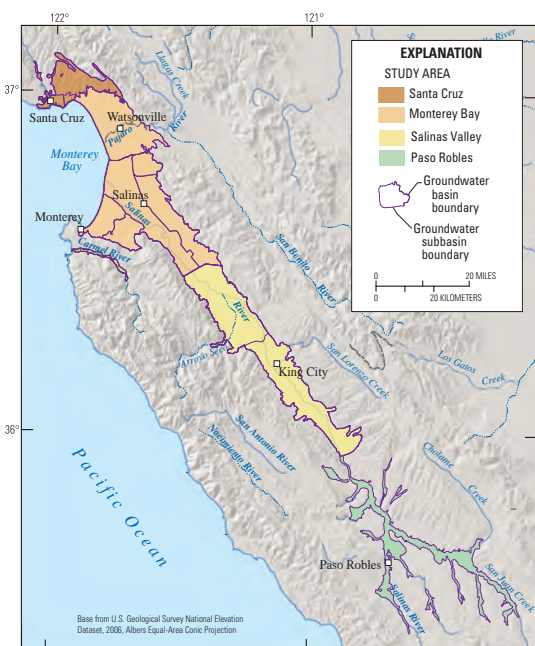


**CONSTITUENT CONCENTRATIONS**  
 ● High ● Moderate ● Low or not detected  
 Values are a percentage of the area of the primary aquifers with concentrations in the three specified categories. Values on piechart may not equal 100 due to rounding of percentages.

GAMA's Priority Basin Project evaluates the quality of untreated groundwater. However, for context, benchmarks established for drinking-water quality are used for comparison. Benchmarks and definitions of *high*, *moderate*, and *low* concentrations are discussed in the inset box on page 3.

Many inorganic constituents occur naturally in groundwater. The concentrations of the inorganic constituents can be affected by natural processes as well as by human activities. In the Monterey-Salinas study unit, one or more inorganic constituents were present at high concentrations in about 15% of the primary aquifers and at moderate concentrations in about 36% of the primary aquifers.

Man-made organic constituents are found in products used in the home, business, industry, and agriculture. Organic constituents can enter the environment through normal usage, spills, or improper disposal. In this study unit, one or more organic constituents were present at high concentrations in less than (<) 1% of the primary aquifers and at moderate concentrations in about 7%.



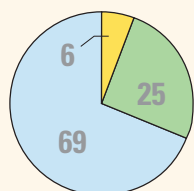
Monterey Formation and Pliocene- to Pleistocene-age Paso Robles Formation, and Pleistocene to Holocene-age alluvium contain freshwater used for supply. The primary aquifers in the study unit are defined as those parts of the aquifers corresponding to the perforated intervals of wells listed in the California Department of Public Health database. Public-supply wells are typically drilled to depths of 200 to 650 feet, consist of solid casing from the land surface to depths of about 175 to 500 feet, and are perforated below the solid casing. Water quality in the primary aquifers may differ from that in the shallower and deeper parts of the aquifer system. Groundwater movement is generally from the southern part of the Salinas Valley north towards the Monterey Bay.

Land use in the study unit is about 44 percent (%) natural (mostly grassland and forests), 43% agricultural, and 13% urban. The primary agricultural uses are row crops, pasture, hay, and vineyards. The largest urban areas are the cities of Santa Cruz, Watsonville, Monterey, Salinas, King City, and Paso Robles.

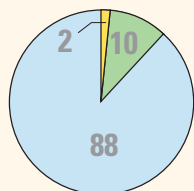
Recharge to the groundwater system is primarily from stream-channel infiltration from the major rivers and their tributaries, and from infiltration of water from precipitation and irrigation. The primary sources of discharge are water pumped for irrigation and municipal supply, evaporation, and discharge to streams.

# RESULTS: Groundwater Quality in the Monterey-Salinas Study Unit

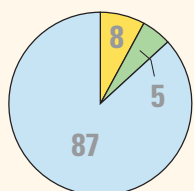
## INORGANIC CONSTITUENTS



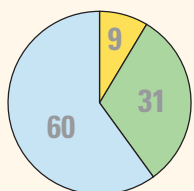
**Trace and minor elements**



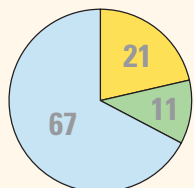
**Radioactive constituents**



**Nutrients**

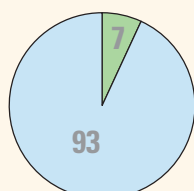


**Total dissolved solids**



**Iron or manganese**

## SPECIAL-INTEREST CONSTITUENTS



**NDMA**

## Inorganic Constituents with Human-Health Benchmarks

Trace and minor elements are naturally present in the minerals in rocks and soils, and in the water that comes into contact with those materials. In the Monterey-Salinas study unit, one or more of the trace elements were present at high concentrations in about 6% of the primary aquifers. Arsenic, boron, and molybdenum were the trace elements that most frequently occurred at high concentrations. Aluminum, cadmium, and lead also were detected at high concentrations, but in less than (<) 1% of the primary aquifers.

Radioactivity is the release of energy or energetic particles during spontaneous decay of unstable atoms. Most of the radioactivity in groundwater comes from the decay of naturally occurring isotopes of uranium and thorium in minerals in the sediments of the aquifer. Gross-alpha radioactivity occurred at high levels in about 2% of the primary aquifers, and at moderate levels in about 10%.

Nutrients, such as nitrate and nitrite, can be naturally present at low concentrations in groundwater. High and moderate concentrations generally occur as a result of human activities, such as applying fertilizer to crops. Livestock, when in concentrated numbers, and septic systems also produce nitrogenous waste that can leach into groundwater. Nitrate was present at high concentrations in about 8% of the primary aquifers, and at moderate concentrations in about 5% of the primary aquifers.

## Inorganic Constituents with Non-Health Benchmarks

*(Not included in water-quality overview charts shown on the front page)*

Some constituents affect the aesthetic properties of water, such as taste, color, and odor, or may create nuisance problems, such as staining and scaling. The State of California has a recommended and an upper limit for total dissolved solids (TDS) in drinking water. Groundwater naturally contains TDS as a result of the weathering and dissolution of minerals in soils. Anoxic conditions in groundwater (very low amounts of dissolved oxygen) may result in release of manganese and iron from minerals into groundwater.

In the Monterey-Salinas study unit, TDS concentrations were high (greater than the upper limit) in about 9% of the primary aquifers. About 31% of the primary aquifers had moderate TDS concentrations (between the recommended and upper limit). Iron and manganese are naturally occurring elements, and one or both were present at high concentrations in about 21% of the primary aquifers, at moderate concentrations in about 11% of the primary aquifers, and at low concentrations in about 67% of the primary aquifers.

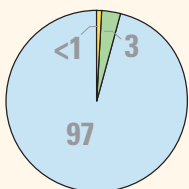
## Perchlorate and *N*-Nitrosodimethylamine (NDMA)

*(Not included in water-quality overview charts shown on the front page)*

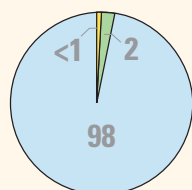
Perchlorate, an inorganic constituent, and NDMA, a semi-volatile organic chemical, are of special interest in California because these constituents have recently been detected in, or are considered to have the potential to affect, drinking-water supplies. Their presence in groundwater is monitored by the California Department of Public Health. NDMA was detected at moderate concentrations in about 7% of the primary aquifers (2 of the 29 wells sampled). Perchlorate was not detected in any of the wells sampled.

# RESULTS: Groundwater Quality in the Monterey-Salinas Study Unit

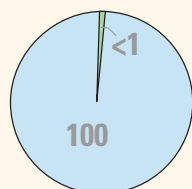
## ORGANIC CONSTITUENTS



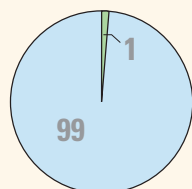
**Solvents**



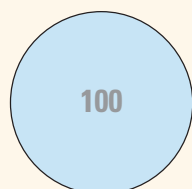
**Gasoline additives**



**Trihalomethanes**



**Insecticides**



**Herbicides and fumigants**

## Organic Constituents

The Priority Basin Project uses laboratory methods that can detect the presence of volatile organic compounds (VOCs) and pesticides at very low concentrations, far below human-health benchmarks. VOCs and pesticides detected at these very low concentrations can be used to help trace water from the landscape into the aquifer system.

## Volatile Organic Compounds with Human-Health Benchmarks

VOCs are in many household, commercial, industrial, and agricultural products and are characterized by their tendency to volatilize (evaporate) into the air.

Solvents are used for a number of purposes, including manufacturing and cleaning. In the Monterey-Salinas study unit, only one of the solvents, tetrachloroethene, was found at a high concentration, and that concentration represented less than (<) 1% of the primary aquifers. Solvents were present at moderate concentrations in about 3% of the primary aquifers and were at low concentrations, or not detected, in about 97%.

Gasoline additives increase the efficiency of fuel combustion. The gasoline additive methyl-*tert*-butyl-ether (MTBE) was detected at high concentrations in <1%, and at moderate concentrations in about 2% of the primary aquifers.

Trihalomethanes may form during municipal water purification and enter groundwater by the infiltration of landscape irrigation water. Trihalomethanes were not detected at high concentrations and were detected at moderate concentrations in <1% of the primary aquifers.

Other organic compounds, which include organic synthesis reagents and refrigerants, were not detected at either high or moderate concentrations.

## Pesticides with Human-Health Benchmarks

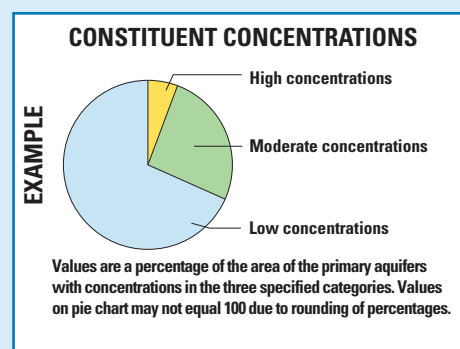
Pesticides are applied to crops, gardens, lawns, around buildings, and along roads to help control unwanted vegetation (weeds), insects, fungi, and other pests. In the Monterey-Salinas study unit, insecticides were not detected at high concentrations in the primary aquifers, but the insecticide dieldrin was detected at moderate concentrations in about 1% of the primary aquifers. Herbicides and fumigants, when detected, were at low concentrations.

## BENCHMARKS FOR EVALUATING GROUNDWATER QUALITY

GAMA's Priority Basin Project uses benchmarks established for drinking water to provide context for evaluating the quality of untreated groundwater. After withdrawal, groundwater may be disinfected, filtered, mixed, and exposed to the atmosphere before being delivered to consumers. Federal and California regulatory benchmarks for protecting human health (Maximum Contaminant Level, MCL) were used when available. Otherwise, nonregulatory benchmarks for protecting aesthetic properties, such as taste and odor (Secondary Maximum Contaminant Level, SMCL), and nonregulatory benchmarks for protecting human health (Notification Level, NL, and Lifetime Health Advisory, HAL) were used.

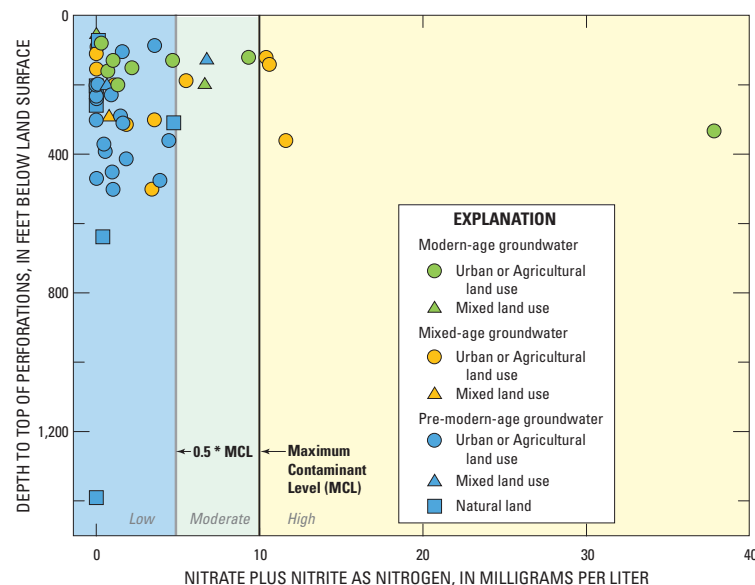
### High, moderate, and low concentrations are defined relative to benchmarks

Concentrations are considered *high* if they are greater than a benchmark. For inorganic constituents, concentrations are *moderate* if they are greater than one-half of a benchmark. For organic and special-interest constituents, concentrations are *moderate* if they are greater than one-tenth of a benchmark; this lower threshold was used because organic constituents are generally less prevalent and have smaller concentrations relative to benchmarks than inorganic constituents. *Low* concentrations include non-detections and values less than moderate concentrations. Methods for evaluating water quality are discussed by Kulongoski and Belitz (2011).



## Factors that Affect Groundwater Quality

In the Monterey-Salinas study unit, nitrate is the constituent that most frequently exists at high concentrations in the primary aquifers (about 8%), and trace elements occur at high concentrations in 6% of the primary aquifers. In contrast, trace elements



nitrate, nitrite, or ammonia. Human activities, such as the application of nitrate as a fertilizer for agriculture, or the production of nitrogen-rich waste from livestock, generate nitrate that can leach into groundwater. Septic systems may also introduce nitrogen-rich waste into groundwater. The human-health regulatory benchmark for nitrate plus nitrite, as nitrogen, is 10 milligrams per liter.

In the Monterey-Salinas study unit, high concentrations of nitrate were found in the shallower wells sampled (top of well perforations less than 400 feet depth) that are located in agricultural and urban areas (see figure above). The groundwaters with high and moderate concentrations of nitrate also were predominantly classified as modern age or mixed age, which indicates that a component of the groundwater was recharged in the past 50 years.

The elevated nitrate concentrations in recently recharged groundwaters from agricultural areas are most likely the result of farming practices that introduced nitrogen at the land surface; however, additional data are needed to confirm the sources of nitrate.

By Justin T. Kulongoski and Kenneth Belitz

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- Landon, M.K., Belitz, Kenneth, Jurgens, B.C., Kulongoski, J.T., and Johnson, T.D., 2010, Status and understanding of groundwater quality in the Central-Eastside San Joaquin Basin, 2006: California GAMA Priority Basin Project: U.S. Geological Survey Scientific Investigations Report 2009-5266, 97 p. Available at <http://pubs.usgs.gov/sir/2009/5266/>

## Priority Basin Assessments

GAMA's Priority Basin Project (PBP) assesses water quality in that part of the aquifer system used for drinking water, primarily public supply. Water quality in the primary aquifers, assessed by the PBP, may differ from that in the deeper parts of the aquifer, or from the shallower parts, which are being assessed by GAMA's Domestic Well Project. Ongoing assessments are being conducted in more than 120 basins throughout California.

The PBP assessments are based on a comparison of constituent concentrations in untreated groundwater with benchmarks established for the protection of human health and for aesthetic concerns. The PBP does not evaluate the quality of drinking water delivered to consumers.

The PBP uses two scientific approaches for assessing groundwater quality. The first approach uses a network of wells to statistically assess the status of groundwater quality. The second approach combines water-quality, hydrologic, geographic, and other data to help assess the factors that affect water quality. In the Monterey-Salinas study unit, data were collected by the PBP in 2005 and from the CDPH database for 2002–2005. The PBP includes chemical analyses not generally available as part of regulatory compliance monitoring, including measurements at concentrations much lower than human-health benchmarks, and measurement of constituents that can be used to trace the sources and movement of groundwater.

### For more information

Technical reports and hydrologic data collected for the GAMA Program may be obtained from

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